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### (54) Aortic graft and apparatus for repairing an abdominal aortic aneurysm

Aortatransplantat sowie Apparat zum Ausbessern eines Aneurysmas der Unterleibsaorta

Greff d'aorte et appareil pour la réparation d'un anévrisme de l'aorte abdominale

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**Description**

The invention relates to an aortic graft for intraluminal delivery, according to the preambl of claim 1, and an apparatus for repairing an abdominal aortic aneurysm. Such a graft is known e.g. from US-A-4 562 596.

An abdominal aortic aneurysm is a sac caused by an abnormal dilation of the wall of the aorta, a major artery of the body, as it passes through the abdomen. The abdomen is that portion of the body which lies between the thorax and the pelvis. It contains a cavity, known as the abdominal cavity, separated by the diaphragm from the thoracic cavity and lined with a serous membrane, the peritoneum. The aorta is the main trunk, or artery, from which the systemic arterial system proceeds. It arises from the left ventricle of the heart, passes upward, bends over and passes down through the thorax and through the abdomen to about the level of the fourth lumbar vertebra, where it divides into the two common iliac arteries.

The aneurysm usually arises in the infrarenal portion of the arteriosclerotically diseased aorta, for example, below the kidneys. When left untreated, the aneurysm will eventually cause rupture of the sac with ensuing fatal hemorrhaging in a very short time. High mortality associated with the rupture has led to the present state of the art and the transabdominal surgical repair of abdominal aortic aneurysms. Surgery involving the abdominal wall, however, is a major undertaking with associated high risks. There is considerable mortality and morbidity associated with this magnitude of surgical intervention, which in essence involves replacing the diseased and aneurysmal segment of blood vessel with a prosthetic device which typically is a synthetic tube, or graft, usually fabricated of either DACRON®, TEFILON®, or other suitable material.

To perform the surgical procedure, requires exposure of the aorta through an abdominal incision, which can extend from the rib cage to the pubis. The aorta must be closed both above and below the aneurysm, so that the aneurysm can then be opened and the thrombus, or blood clot, and arteriosclerotic debris removed. Small arterial branches from the back wall of the aorta are tied off. The DACRON® tube, or graft, of approximately the same size of the normal aorta is sutured in place, thereby replacing the aneurysm. Blood flow is then reestablished through the graft. It is necessary to move the intestines in order to get to the back wall of the abdomen prior to clamping off the aorta.

If the surgery is performed prior to rupturing of the abdominal aorta aneurysm, the survival rate of treated patients is markedly higher than if the surgery is performed after the aneurysm ruptures, although the mortality rate is still quite high. If the surgery is performed prior to the aneurysm rupturing, the mortality rate is typically less than 5%. Conventional surgery performed after the rupture of the aneurysm is significantly higher, one study reporting a mortality rate of 66.7%. Although abdominal aortic aneurysms can be detected from rou-

tine examinations, the patient does not experience any pain from the condition. Thus, if the patient is not receiving routine examinations, it is possible that the aneurysm will progress to the rupture stage, wherein the mortality rates are significantly higher.

Disadvantages associated with the conventional, prior art surgery, in addition to the high mortality rate, are: the extended recovery period associated with such surgery; difficulties in suturing the graft, or tube, to the aorta; the loss of the existing thrombosis to support and reinforce the graft; the unsuitability of the surgery for many patients having abdominal aortic aneurysms; and the problems associated with performing the surgery on an emergency basis after the aneurysm has ruptured.

As to the extent of recovery, a patient can expect to spend from 1 to 2 weeks in the hospital after the surgery, a major portion of which is spent in the intensive care unit, and a convalescence period at home from 2 to 3 months, particularly if the patient has other illness such as heart, lung, liver, and/or kidney disease, in which case the hospital stay is also lengthened. Since the graft must be secured, or sutured, to the remaining portion of the aorta, it is many times difficult to perform the suturing step because of thrombosis present on the remaining portion of the aorta, and that remaining portion of the aorta wall may many times be friable, or easily crumbled.

US-A-3657744 describes a modification to such conventional aortic grafts, in which, to avoid the need for suturing of the graft to the aorta, an expandable sleeve fixation system is provided on the graft. After inserting the expandable sleeve into the opened end of the aorta, the sleeve is expanded by the application, from the interior of the sleeve, of a radially outwardly extending force provided by an expander tool. The sleeve is so arranged that a multitude of narrow projecting edges thereof embed themselves into the tissue wall upon expansion of the sleeve. This is said to avoid the need for suturing.

However, for reasons such as mentioned below, open-abdomen surgery to repair abdominal aortic aneurysms is generally unsatisfactory.

Since the thrombosis is totally removed in the prior art surgery, the new graft does not have the benefit of the previously existing thrombosis therein, which could be utilized to support and reinforce the graft, were the graft to be able to be inserted within the existing thrombosis. Since many patients having abdominal aortic aneurysms have other chronic illnesses, such as heart, lung, liver, and/or kidney disease, coupled with the fact that many of these patients are older, the average age being approximately 67 years old, these patients are not ideal candidates for such surgery, which is considered major surgery. Such patients have difficulties in surviving the operation. Lastly, once the aneurysm has ruptured, it is difficult to perform a conventional surgery on an expedited basis because of the extent of the surgery.

The use of intraluminal delivery of aortic grafts to enable repair of abdominal aortic aneurysms has been proposed. US-A-4562596 describes an aortic graft for

intraluminal delivery to repair an abdominal aortic aneurysm in an aorta having two iliac arteries associated therewith, comprising: a tube having first and second ends and a wall surface disposed between the two ends, at least a portion of the tube adapted to be disposed within the abdominal aortic aneurysm; and means for securing the first end of the tube to the aorta. The securing means includes outwardly extending hooks and barbs arranged around the first end of the tube, which may be advanced into, and pierce, the blood vessel to secure the tube in position.

The perforation of the healthy aorta wall can lead to blood leakage, and is generally undesirable. US-A-4562596 seeks to overcome this problem by providing a flexible ring at the first end of the tube, which ring expands under a radially outwardly extending restoring force after location of the graft in position. However, this system does not avoid the problems associated with perforation of the healthy aorta.

Accordingly, prior to the development of the present invention, there has been no graft for intraluminal delivery, or method and apparatus for repairing an abdominal aortic aneurysm, which: does not have a relatively high morbidity and mortality rate; does not have an extended recovery period; is suitable for older patients with chronic illnesses; and is more readily performed on an emergency basis after rupture of the aneurysm. Therefore, the art has sought an aortic graft for intraluminal delivery, and method and apparatus for repairing an abdominal aortic aneurysm which is believed to: not have a high morbidity and mortality rate; not require an extended recovery period; be suitable for patients having other chronic illnesses; and be more readily, quickly performed on an emergency basis after rupture of the aneurysm.

In accordance with the invention, the foregoing advantages have been achieved through the present aortic graft for intraluminal delivery to repair an abdominal aortic aneurysm in an aorta having two iliac arteries associated therewith. The aortic graft of the present invention is as defined in the appended claims. In brief, the present invention provides the improvement and modification that the graft securing means includes a thin-walled member having first and second ends and a wall having an outer wall surface disposed between the first and second ends, the first end of the tube being connected to the second end of the thin-walled member. The thin-walled member has a first diameter which permits intraluminal delivery of the thin-walled member into the aorta and a second, expanded and deformed, diameter upon application from the interior of the thin-walled member of a radially, outwardly extending force, which second diameter is variable and dependent upon the amount of force applied to the thin-walled member. In further contrast to the prior art, the outer wall surface of the thin-walled member is sufficiently smooth that a sheath enclosing the tube and thin-walled member for intraluminal delivery thereof into the aorta may be removed by sliding the sheath over the outer wall sur-

face while the tube and thin-walled member are in position in the aorta, whereby after removal of any such sheath the thin-walled member may be expanded into contact with the aorta to remain secured thereto to secure the thin-walled member and the first end of the tube to the aorta.

The thin-walled member of the graft may suitably be tubular and the wall thereof may suitably have a substantially uniform thickness. A plurality of slots may suitably be formed therein, the slots being suitably disposed substantially parallel to the longitudinal axis of the thin-walled member.

A further feature of the present invention is that the second end of the tube may be bifurcated and two tubular passageways are formed which are in fluid communication with the first end of the tube and the two passageways are adapted to be mated with and disposed within the two iliac arteries. Another feature of the present invention is that the two tubular passageways may include means for securing the two tubular passageways to the two iliac arteries, and the securing means may be a thin-walled tubular member which has a first diameter which permits intraluminal delivery of the tubular member into the aorta, the tubular member having a second, expanded and deformed diameter, upon the application from the interior of the tubular member of a radially, outwardly extending force, which second diameter is variable and dependent upon the amount of force applied to the tubular member, whereby the tubular member may be expanded and deformed to secure the tubular member to the iliac artery. A further feature of the present invention is that the first end of the tube which may be secured to the second end of the tubular member is radially expandable, whereby the first end of the tube may conform with the second expanded and deformed diameter of the second end of the tubular member. An additional feature of the present invention is that the tube may have an intermediate portion which is not substantially radially expandable. Another feature of the present invention is that the tube may be bio-erodible, and it may be impervious to the flow of fluid through the wall surface of the tube.

In accordance with the invention, the foregoing advantages have also been achieved through the present apparatus for repairing an abdominal aortic aneurysm. The apparatus of the present invention includes: a tube having first and second ends and a wall surface disposed between the two ends; an expandable and deformable, thin-walled tubular member having first and second ends and a smooth outer wall surface disposed between the first and second ends, the first end of the tube being secured to the second of the tubular member, and the expansion and deformation of the thin-walled tubular member being controllable; and a catheter having an expandable, inflatable portion associated therewith, the thin-walled tubular member being releasably mounted upon the inflatable portion of the catheter, whereby upon inflation of the expandable, inflatable portion of the catheter, the thin-walled tubular member is

forced radially outwardly into contact with the aorta to remain secured thereto, whereby the tube, secured to the thin-walled tubular member, provides a passageway through the abdominal aortic aneurysm.

The invention enables an advantageous new method for repairing an abdominal aortic aneurysm in an aorta having two iliac arteries. The method comprises the steps of: connecting a tube to an expandable and deformable, tubular member; disposing the tube and tubular member upon a catheter having an expandable, inflatable portion with the tubular member disposed upon the expandable, inflatable portion; intraluminally delivering the tube, tubular member and catheter to the aorta and disposing at least a portion of the tube within the abdominal aortic aneurysm; expanding the expandable, inflatable portion of the catheter to expand and deform the tubular member to force the tubular member radially outwardly into contact with the aorta to secure the tubular member and at least a portion of the tube within the aorta, whereby the tube provides a fluid passageway through the abdominal aortic aneurysm.

Another feature of the method is that the tube may have first and second ends, the first end of the tube being connected to the tubular member and the second end of the tube being bifurcated to form two tubular passageways, and the passageway is disposed in each iliac artery. A further feature of the method includes the steps of:

30 connecting an expandable and deformable tubular member to each of the tubular passageways; disposing each tubular member within an iliac artery; expanding and deforming each tubular member with a catheter to secure each tubular member and associated fluid passageway within an iliac artery.

An additional feature of the method includes the steps of providing a biologically inert coating on the tube. A further feature of the method is utilizing a tube made of a material which is impervious to the flow of fluid or utilizing a tube made of a material which is biodegradable. Another feature of the method is that the tube, tubular member, and catheter may be intraluminally delivered through a femoral artery. Another feature of the method is that the tube, tubular member, and catheter may be intraluminally delivered through an axillary artery.

The aortic graft for intraluminal delivery, and the apparatus for repairing an abdominal aortic aneurysm of the present invention, and the method thereby enabled, when compared to previously proposed prior art grafts and methods and apparatus for repairing aneurysms, are believed to have the advantages of: a lower mortality rate; shortened recovery periods; utilizing, in contrast to open-abdomen surgery, the existing aortic wall and thrombosis therein to support and reinforce the aortic graft; being suitable for use with patients having other chronic illnesses; and being able to be expeditiously used on an emergency basis after an aneurysm has ruptured.

In the drawings:

5 FIG. 1 is a partial cross-sectional view of an abdominal aortic aneurysm in the process of being repaired by a graft and apparatus in accordance with the present invention;

10 FIG. 2 is a partial cross-sectional view of a portion of the aorta of FIG. 1, illustrating the expansion of a portion of an aortic graft;

15 FIG. 3 is a partial cross-sectional view of the aorta of FIG. 2, illustrating the portion of the aortic graft being fully expanded;

20 FIG. 4 is a partial cross-sectional view of an aorta with the aortic graft of the present invention having been used to repair an abdominal aortic aneurysm;

25 FIG. 5 is a perspective view of an apparatus for repairing an abdominal aortic aneurysm;

30 FIGS. 6-8 illustrate different embodiments of an aortic graft in accordance with the present invention, such grafts being disposed within an abdominal aortic aneurysm and/or iliac aneurysm;

35 FIGS. 9-12 are partial cross-sectional views of an abdominal aortic aneurysm, illustrating one embodiment of the method enabled by the present invention for repairing an abdominal aortic aneurysm and iliac aneurysm;

40 FIG. 13 is a partial cross-sectional view of a patient with a ruptured abdominal aortic aneurysm, which rupture is being repaired by means of a graft and apparatus in accordance with the present invention;

45 FIG. 13a is an enlarged partial cross-sectional view of a portion of FIG. 13; and

50 FIG. 14 is a partial cross-sectional view along the longitudinal axis of an apparatus for repairing an abdominal aortic aneurysm, after the aneurysm has ruptured.

55 While the invention will be described in connection with the preferred embodiment, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

In FIGS. 1-4 an aortic graft 150 for intraluminal delivery to repair an abdominal aortic aneurysm 151 in an aorta 152 having two iliac arteries 153L, 153R associated therewith is illustrated. Aortic graft 150, as well as other grafts to be hereinafter described, could also be utilized in the thoracic aorta, and can be used to repair thoracic aneurysms or thoracic dissecting aneurysms. Accordingly, use of the term "abdominal aortic aneurysm" in this specification and claims is intended to relate to and mean both abdominal aortic aneurysms and thoracic aneurysms. Aneurysm 151 includes areas of thrombosis 154, which are disposed against the interior wall surface 155 of aorta 152. Blood flows through

the aorta in the direction of arrows 156. Associated with aorta 152, above aneurysm 151, are a plurality of renal arteries 157, in fluid communication with aorta 152. Aortic graft 150 is seen to generally comprise: a tube 160 having first and second ends 161, 162 and wall surface 163 disposed between the two ends, at least a portion of the tube 160 adapted to be disposed within the aneurysm 151; and means for securing 165 the first end 161 of the tube 160 to the aorta 152.

Preferably, securing means 165 includes a thin-walled member 166 having first and second ends 167, 168 and a smooth outer wall surface 169 disposed between the first and second ends 167, 168 of the thin-walled member 166. The thin-walled member 166 has a first diameter D' (FIG. 1), which permits intraluminal delivery of the thin-walled member 166 into the aorta 152. Upon the application from the interior of the thin-walled member 166 of a radially, outwardly extending force, as will be hereinafter described in greater detail, the thin-walled member 166 has a second, expanded and deformed diameter D" (FIGS. 3 and 4), whereby the thin-walled member 166 is expanded and deformed to secure the first end 167 of the thin-walled member 166 and the first end 161 of the tube 160 to the aorta 152. The second diameter D", as will be hereinafter described in greater detail, is variable and dependent upon the amount of force applied to the thin-walled member 166. The first end 161 of tube 160 is connected to the second end 168 of the thin-walled member 166, as by a plurality of sutures 170 (FIG. 2). Sutures 170 may be conventional sutures of polypropylene, DACRON®, or any other suitable material. Preferably, the first end 161 of tube 160 overlaps and covers the second end 168 of thin-walled member 166, such overlap being approximately 50% of the length of thin-walled member 166. The first end 161 of tube 160, which overlaps the second end 168 of thin-walled member 166, is preferably constructed so that it is radially expandable, whereby the first end 161 of tube 160 may conform with the second, expanded and deformed diameter D" of the second end 168 of the thin-walled member 166 as seen in FIGS. 3 and 4. If tube 160 is woven, the weave of the material at its first end 161 is looser, so that the desired radial expansion can be obtained. The intermediate portion 171 of tube 160 disposed between first and second ends 161, 162 thereof, is preferably not substantially radially expandable.

Still with reference to FIGS. 1-4, thin-walled member 166 is preferably a thin-walled tubular member 172 whose wall surface 169 has a substantially uniform thickness with a plurality of slots 173 (FIGS. 1 and 5) formed therein, the slots 173 being disposed substantially parallel to the longitudinal axis of the tubular member 172. It has been found that one type of thin-walled member 166, or tubular member 172, which is particularly useful as securing means 165 are the expandable intraluminal grafts disclosed in US Patent No. 4733665, issued March 29, 1988; US Patent No. 4739762, issued April 26, 1988; and US Patent N. 4776337, issued

5 October 11, 1988, all the foregoing patents being in the name of Julio C. Palmaz, and assigned to Expandable Grafts Partnership. One example of such a securing means is the arrangement wherein the slots have a substantially rectangular configuration when the tubular member has the first diameter, and the slots have a substantially hexagonal configuration when the tubular member has the second, expanded, diameter. Other thin-walled members 166, or tubular members 172 could be utilized as securing means 165, provided they have ability to be controllably expanded and deformed from the first diameter D', which permits intraluminal delivery of securing means 165, to the second expanded and deformed diameter D", in order to secure the thin-walled member 166, and connected tube 160 within aorta 152.

20 Still with reference to FIGS. 1-4, tube 160, preferably has a generally, circular cross-sectional configuration, and tube 160 may be made from a variety of materials, provided they have the requisite strength characteristics to be utilized as an aortic graft 150, as well as have the requisite compatibility with the human body in order to be used as a graft, or implant material, without being rejected by the patient's body. Examples 25 of such materials are DACRON® and other polyester materials, TEFLON® (polytetrafluoroethylene), TEFLON® coated DACRON® material and porous polyurethane. The material can be knitted or woven, and can be warp or weft knitted. If the material is warp 30 knitted, it may be provided with a velour, or towel like surface, which speeds up clotting of blood which contacts tube 160 in order to increase the attachment, or integration, of tube 160 to aorta 152, or to assist the integration of tube 160 to the thrombosis 154. Tube 160 35 can also be made of a bio-erodable, or degradable material, such as albumin or collagen or a collagen coated material. A tube 160 which is bio-erodable, would erode and dissolve, or degrade, over a period of time; however, it is believed that a layer of endothelium, 40 or skin, will grow as the tube 160 erodes, the new layer of endothelium, or skin, providing a new, fluid impervious lining within aneurysm 151. As will be hereinafter described in greater detail, when aortic graft 150 is utilized in connection with an emergency insertion after a 45 rupture of aneurysm 151, it would be preferable to make tube 160 of a fluid impervious material. Additionally, the tube 160 or securing means 165 could have a coating of a biologically inert material, such as TEFLON® or porous polyurethane.

50 Still with reference to FIGS. 1-4 tube 160 may have a crimped configuration to form an undulating longitudinal cross-sectional configuration (FIG. 1), whereby kinking, or twisting, or folding over upon itself will be minimized when the tube 160 is secured within the aneurysm 151, as will be hereinafter described in greater detail. This undulating configuration can be obtained by heat stamping tube 160, or in any other suitable manner, whereby the tube 160 has a "memory" 55 and if it is twisted or kinked, it will return to its original

configuration and disposition. Alternatively, tube 160 can have a smooth outer surface.

With reference to FIGS. 1-4, and FIG. 5, an apparatus 180 for repairing an abdominal aortic aneurysm 151 generally comprises: tube 160; expandable and deformable thin-walled member 166, or tubular member 172 which preferably includes slots 173 and has a smooth outer wall surface 169, the expansion and deformation of the thin-walled member 166 being controllable, as will hereinafter be described in greater detail; and a catheter 181 having an expandable, inflatable portion 182, or balloon 183 associated therewith and a nosepiece 184. The thin-walled member 166, or tubular member 172, is releasably mounted to the inflatable portion 182 of catheter 181, in any suitable fashion, whereby upon inflation of the expandable, inflatable portion 182 of catheter 181, the thin-walled member 166 is forced radially outwardly into contact with the aorta 152 to remain secured thereto, whereby the tube 160, secured to the thin-walled member 166, provides a passageway 185 (FIG. 4) through the abdominal aortic aneurysm 151, so that blood can pass through the aneurysm 151 and be separated therefrom. As seen in FIG. 4, the existing aortic wall 152' and the thrombosis 154 therein provide additional support and reinforcement for tube 160 of aortic graft 150.

The apparatus 180 for repairing the abdominal aortic aneurysm 151 as illustrated in FIG. 5 is in its configuration it would have for intraluminal delivery, as also illustrated in FIG. 1. In the configuration shown in FIG. 5, the thin-walled member 166 has its first unexpanded, undeformed diameter D', and balloon 183 is shown partially inflated in FIG. 2, and completely inflated in FIG. 3. Expansion and deformation of thin-walled member 166 is controlled by the expansion of balloon 183 of catheter 181, in a conventional manner. When apparatus 180 is being intraluminally delivered, catheter 181, thin-walled member 166, and tube 160 are preferably enclosed by a conventional catheter sheath 186 which is removed, as shown in FIG. 1, as apparatus 180 is disposed in its desired location within aorta 152, as will hereinafter be described in greater detail. Deflation of balloon 183 permits the withdrawal of catheter 181 and release of the balloon 183 and catheter from aortic graft 150 after it has been disposed in the configuration shown in FIG. 4.

With reference to FIGS. 6 and 8, various embodiments of grafts 150 are illustrated within aorta 152 and aneurysm 151 after aneurysm 151 has been repaired through the use of aortic graft 150 and apparatus 180. In FIG. 6, aortic graft 150' includes tube 160 as previously described, and graft 150' is secured by use of thin-walled member 166 as previously described. Abdominal aortic aneurysm 151 also includes two iliac artery aneurysms 190, which also contain the same thrombosis 154 disposed within aneurysm 151. Aortic graft 150' of FIG. 6 has the second end 162 of tube 160 bifurcated, so that two tubular passageways 191 are formed which are each in fluid communication with the first end 161 of tube 160, and the fluid passageways 191 are mated

with and disposed within the two iliac arteries 153.

The aortic graft 150' of FIG. 7 is the same as graft 150' of FIG. 6, except that the two tubular passageways 191 include means for securing the two tubular passageways 191 to the two iliac arteries 153. Securing means 192 preferably are thin-walled members 166, or tubular members 172, of the same type of construction as those used for securing means 165. Securing means 192 may be expanded and deformed in the same manner as securing means 165 by controlled inflation of the expandable, inflatable portion 182 of catheter 181. In this regard, catheter 181 of apparatus 180 of FIG. 5 may include a second expandable, inflatable portion 182 (not shown) spaced longitudinally from the first expandable, inflatable portion 182, so that securing means 165 and 192 may be expanded and deformed simultaneously. Alternatively, apparatus 180 as shown in FIG. 5 could be utilized to first expand and deform securing means 165 disposed at the upper end 161 of tube 160, and the expandable, inflatable portion 182 could then be deflated and moved downwardly toward second securing means 192. The expandable, inflatable portion 182 would then be re-expanded and inflated to deform and expand securing means 192. Although the flow of pumped blood downwardly through aorta 152 and into iliac arteries 153 is believed to provide enough pressure to maintain passageway 191 in their desired positions, there is a slight negative vacuum pressure component associated with the pumping pressure, whereby the securing means 192 might be required. Securing means 192 also serves to insure no movement of passageways 191, caused by body movements.

In some instances, aneurysm 151 could extend above the renal arteries 157, as shown in dotted lines 195 in FIG. 7. In order to secure aortic graft 150' to repair such an aneurysm 151, 195, it is preferable to use a securing means 165' which includes first and second thin-walled members 166 and 166', or tubular members 172, 172', which are flexibly interconnected by at least one connector member 196, the first end 161 of tube 160 being secured, as previously described, to the second end 168 of thin-walled member 166 in the manner previously described. The flexible connector member 196 spans the part of the aorta 152 adjacent the renal arteries 157, so that fluid flow through renal arteries 157 is not obstructed. Preferably, two connector members 196 are utilized, the connector members being disposed 180° apart, whereby the surgeon can determine by x-ray or fluoroscopy that the two flexible connector members 196 are disposed in the position shown in FIG. 7, wherein the second connector member (not shown) is disposed directly behind the first connector member 196. If two images of connector members 196 appear on the x-ray or the fluoroscope, the surgeon will know that it is possible that one of the renal arteries 157 may be obstructed by one of the connector members 196. Securing means 165' is expanded and deformed in the same manner as previously described with respect to securing means 165.

With reference to FIG. 8, a graft 150" is illustrated, graft 150" being similar in design to the graft 150 illustrated in FIG. 4, with the exception that the second end 162 of tube 160 is provided with additional securing means 192 as previously described in connection with FIG. 7.

With reference to FIGS. 9-12, a method for repairing an abdominal aortic aneurysm 151 and iliac aneurysm 190 with an aortic graft 150" as illustrated in FIG. 6 will be described. After tube 160 has been connected to an expandable and deformable thin-walled member 166, or tubular member 172, as previously described in connection with FIGS. 1-5, a surgical wire 200 is introduced through a conventional catheter insertion device 201 through the right femoral artery 202R. In a conventional manner, the surgical wire 200 is passed from the right femoral artery 202R upwardly through the right iliac artery 153R through the aorta 152 and downwardly through the left iliac artery 153L and into the left femoral artery 202L and into another conventional catheter insertion device 201. Apparatus 180, including tube 160, catheter 181, and thin-walled member 166" are then intraluminally delivered into the aorta 152 and aneurysm 151, through the left femoral artery 202L, via a conventional catheter insertion device 201. Securing means 165 can be disposed in the aorta 152 in the position shown in FIGS. 9 and 1. Sheath 186 may then be removed in a conventional manner. With reference to FIGS. 10 and 11, after sheath 186 is removed, surgical wire 200 may then be sutured to the right passageway 191R of tube 160 as shown in FIG. 10. Securing means 165 may then be expanded and deformed in the manner previously described, as shown in FIG. 11. The wire 200 can then be withdrawn and pulled, so as to pull the right passageway 191R of tube 160 downwardly into the right iliac artery 153R until it assumes the position shown in FIG. 12. This same method could also be utilized to repair an aneurysm 151, including an iliac aneurysm 191 with the graft 150" of FIG. 7.

With reference to FIGS. 13, 13a, and 14, a method and apparatus for repairing an abdominal aortic aneurysm 151 which has ruptured as shown at 250 in FIGS. 13 and 13a is illustrated. As seen in FIG. 13a, blood is illustrated by arrows 251 as flowing through the opening, or rupture, 250 in the wall 252 of aorta 152, and the thrombosis 154 is separated from wall 252. Apparatus 180", as shown in FIG. 14, is similar to apparatus 180 previously described in connection with FIG. 5. Apparatus 180" includes tube 160 of the type as previously described, a catheter 181" having an extended nosepiece 184", tube 160 being disposed about the extended nosepiece 184". Securing means 165, as previously described, is mounted upon an expandable, inflatable portion 183 of catheter 181". Apparatus 180" differs from that previously described, in that catheter 181" first passes through securing means 165 and then into tube 160, whereas in apparatus 180, catheter 181 first passes through tube 160 and then into securing means 165. Sheath 186 is also provided as previously

described. Additionally, the second end 162 of tube 160 is restrained in the position shown in FIG. 14, as by a thread which passes through the lower end 162 of tube 160, the thread 260 passing through the extended catheter nosepiece 184". As will hereinafter be described in greater detail, it is preferable that thread 260 be able to be easily pulled through tube 160. Accordingly, it is preferred that thread 260 have a smooth, slippery surface. Nylon monofilament is thus a preferred material for thread 260.

As seen in FIG. 13, apparatus 180" is intraluminally delivered to the aorta and the ruptured aneurysm 151 through an axillary artery 261 in the patient's arm 262 whereby apparatus 180" is intraluminally delivered via the axillary artery downwardly through the aorta 152 into the position illustrated in FIGS. 13 and 1. Securing means 165 is then expanded and deformed in the manner previously described, so that aortic graft 150 assumes the configuration illustrated in FIGS. 4 and 13. Thread 260 is then pulled and removed from tube 160 by pulling it out through nosepiece 184". In the event of a rupture 250, it is believed it would be difficult to enter the aorta 152 from the femoral artery, where as it is believed it will be readily possible to intraluminally deliver apparatus 180" through the axillary artery 261 via usage of a conventional catheter insertion device 201. Because of the rapid flow of blood, it is preferred that the tube 160 be made fluid impervious when used for repairing aneurysms which have ruptured. It should be readily recognized that the procedure illustrated in connection with FIGS. 13, 13a, and 14 can be much more expeditiously performed than the conventional, prior art method for repairing a ruptured aneurysm 151.

It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials or embodiments shown and described, as obvious modifications and equivalents will be apparent to one skilled in the art. For example, the expandable, inflatable portion of the catheter could be a plurality of hydraulically actuated rigid members disposed on a catheter or a plurality of balloons could be utilized to expand the securing means. Additionally, the wall surface of the thin-walled member could be formed by a plurality of wires having a smooth exterior surface. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.

#### Claims

1. An aortic graft (150) for intraluminal delivery to repair an abdominal aortic aneurysm (151) in an aorta (152) having two iliac arteries (153L, 153R) associated therewith, comprising: a tube (160) having first and second ends (161, 162) and a wall surface (163) disposed between the two ends, at least a portion of the tube (160) adapted to be disposed within the abdominal aortic aneurysm (151); and means (165) for securing the first end (161) of the tube (160) to the aorta (152), characterised in that

the securing means (165) includes a thin-walled member (166 or 172) having first and second ends (167, 168) and a wall having an outer wall surface (169) disposed between the first and second ends (167, 168), the first end (161) of the tube (160) being connected to the second end (168) of the thin-walled member (166 or 172); in that the thin-walled member (166 or 172) has a first diameter (D') which permits intraluminal delivery of the thin-walled member into the aorta and a second, expanded and deformed, diameter (D'') upon the application from the interior of the thin-walled member of a radially, outwardly extending force, which second diameter (D'') is variable and dependent upon the amount of force applied to the thin-walled member (166 or 172); and in that the outer wall surface (169) of the thin-walled member is sufficiently smooth that a sheath (186) enclosing the tube (160) and thin-walled member (166 or 172) for intraluminal delivery thereof into the aorta may be removed by sliding the sheath over the outer wall surface (169) while the tube (160) and thin-walled member (166 or 172) are in position in the aorta; whereby after removal of any such sheath (186) the thin-walled member may be expanded into contact with the aorta to remain secured thereto to secure the thin-walled member (166 or 172) and the first end of the tube (160) to the aorta.

2. The aortic graft of claim 1, wherein the thin-walled member (166 or 172) is tubular and the wall thereof has a substantially uniform thickness and a plurality of slots (173) formed therein, the slots being disposed substantially parallel to the longitudinal axis of the thin-walled member.

3. The aortic graft of claim 2, wherein the slots (173) are uniformly and circumferentially spaced from adjacent slots and the slots are uniformly spaced from adjacent slots along the longitudinal axis of the tubular member (166 or 172), whereby at least one elongate member is formed between adjacent slots.

4. The aortic graft of claim 3, wherein each slot (173) has first and second ends, and the first and second ends of each slot are disposed intermediate the first and second ends of adjacent slots along the longitudinal axis of the tubular member.

5. The aortic graft of any one of the preceding claims, wherein the thin-walled member (166 or 172) does not exert any outward, radial force while the member has the first (D') or second, expanded (D''), diameter.

6. The aortic graft of any one of claims 2 to 5, wherein the slots (173) have a substantially rectangular configuration when the tubular member has the first

5 7. The aortic graft of any one of the preceding claims, wherein the thin-walled member has a biologically inert coating on the wall surface.

10 8. The aortic graft of any one of the preceding claims, wherein the second end of the tube is bifurcated and two tubular passageways (191) are formed which are in fluid communication with the first end (161) of the tube (160) and the two passageways (191) are adapted to be mated with and disposed within two iliac arteries (153L, 153R).

15 9. The aortic graft of claim 8, wherein the two tubular passageways (191) include means (192) for securing the two tubular passageways to the two iliac arteries.

20 10. The aortic graft of claim 9, wherein the securing means includes a thin-walled tubular member having first and second ends and a smooth outer wall surface disposed between the first and second ends, the wall surface having a substantially uniform thickness and a plurality of slots formed therein, the slots being disposed substantially parallel to the longitudinal axis of the tubular member, the fluid passageways being secured to the first end of the tubular member; the tubular member having a first diameter which permits intraluminal delivery of the tubular member into the aorta and the tubular member having a second, expanded and deformed diameter, upon the application from the interior of the tubular member of a radially outwardly extending force, which second diameter is variable and dependent upon the amount of force applied to the tubular member, whereby the tubular member may be expanded and deformed to secure the second end of the tubular member and the tubular passageways to the two iliac arteries.

25 11. The aortic graft of any one of the preceding claims, wherein the first end (161) of the tube (160) is secured to the second end (168) of the thin-walled member (166 or 172) by a plurality of sutures.

30 12. The aortic graft of any one of the preceding claims, wherein the first end (161) of the tube (160) which is secured to the second end (168) of the thin-walled member (166 or 172) is radially expandable, whereby the first end of the tube may conform with the second expanded and deformed diameter (D'') of the second end of the thin-walled member.

35 13. The aortic graft of any one of the preceding claims, wherein the tube (160) has an intermediate portion (171) which is not substantially radially expandable.

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14. The aortic graft of any one of the preceding claims, wherein the tube (160) is crimped to form an undulating longitudinal cross-sectional configuration, whereby kinking or twisting of the tube is minimized. 5

15. The aortic graft of any one of the preceding claims, wherein the securing means (165) includes first and second tubular members (172, 172) flexibly interconnected by at least one connector member (196), the first end of the tube (160) being secured to one of the tubular members. 10

16. The aortic graft of any one of the preceding claims, wherein the tube (160) is bioerodable. 15

17. The aortic graft of any one of the preceding claims, wherein the tube (160) is impervious to the flow of fluid through the wall surface of the tube. 20

18. The aortic graft of any one of the preceding claims, wherein thin-walled member (166 or 172) is tubular and the first end (161) of the tube (160) overlaps and covers the second end of the tubular member. 25

19. The aortic graft of claim 18, wherein the overlap is approximately 50% of the length of the tubular member. 30

20. An apparatus (180) for repairing an abdominal aortic aneurysm (151) in an aorta (152) having two iliac arteries (153L, 153R) associated therewith, comprising: 35

(a) a tube (160) having first and second ends (161, 162) and a wall surface (163) disposed between the two ends;

(b) an expandable and deformable thin-walled tubular member (166 or 172), having first and second ends (167, 168) and an outer wall surface (169) disposed between the first and second ends (167, 168), the first end (161) of the tube (160) being secured to the second end (168) of the tubular member (166 or 172), the expansion and deformation of the thin-walled tubular member being controllable; the outer wall surface (169) of the thin-walled member being sufficiently smooth that a sheath (186) enclosing the tube (160) and thin-walled member (166 or 172) for intraluminal delivery thereof into the aorta may be removed by sliding the sheath over the outer wall surface (169) while the tube (160) and thin-walled member (166 or 172) are in position in the aorta; whereby after removal of any such sheath (186) the thin-walled member may be expanded into contact with the aorta to remain secured thereto to secure the thin-walled mem- 40

ber (166 or 172) and the first end of the tube (160) to the aorta; and 45

(c) a catheter (181) having an expandable, inflatable portion (182) associated therewith, the thin-walled tubular member being releasably mounted upon the inflatable portion of the catheter, whereby upon inflation of the expandable, inflatable portion (182) of the catheter, the thin-walled tubular member (166 or 172) is forced radially outwardly into contact with the aorta to remain secured thereto, whereby the tube (160), secured to the thin-walled tubular member, provides a passageway through the abdominal aortic aneurysm. 50

#### Patentansprüche

1. Hauptschlagaderimplantat (150) zur Einführung ins Gefässinnere, um ein Unterleibs-Hauptschlagaderaneurysma (151) in einer Hauptschlagader (152), mit der zwei Hüftschlagadern (153L, 153R) verbunden sind, zu beheben, das Implantat bestehend aus: einem Schlauch (160) mit einem ersten und zweiten Ende (161, 162) und einer Wandungsoberfläche (163) zwischen den beiden Enden, wobei zumindest ein Abschnitt des Schlauches (160) dafür geeignet ist, innerhalb des Unterleibs-Hauptschlagaderaneurysmas (151) angeordnet zu werden; sowie Mitteln (165), um das erste Ende (161) des Schlauchs (160) an der Hauptschlagader (152) zu befestigen, dadurch gekennzeichnet, dass zu den Befestigungsmitteln (165) ein dünnwandiges Glied (166 oder 172) gehört, das ein erstes und zweites Ende (167, 168) sowie eine Wandung hat, deren äussere Oberfläche (169) zwischen dem ersten und zweiten Ende (167, 168) angeordnet ist, wobei das erste Ende (161) des Schlauches (160) mit dem zweiten Ende (168) des dünnwandigen Gliedes (166 oder 172) verbunden ist; das dünnwandige Glied (166 oder 172) einen ersten Durchmesser (D) hat, der die Einführung des dünnwandigen Gliedes in den Innenraum der Hauptschlagader gestattet, sowie einen zweiten, aufgeweiteten und verformten Durchmesser (D'), der sich nach Anwendung einer radial nach aussen wirkenden Kraft vom Inneren des dünnwandigen Gliedes her ergibt und je nach der Grösse der auf das dünnwandige Glied (166 oder 172) ausgeübten Kraft verschieden gross ist; und die äussere Wandungsoberfläche (169) des dünnwandigen Gliedes genügend glatt ist, damit eine den Schlauch (160) und das dünnwandige Glied (166 oder 172) umschliessende Hülle (186), die deren Einführung in das Innere der Hauptschlagader dient, entfernt werden kann, indem die Hülle über die äussere Wandungsoberfläche (169) geschoben wird, während der Schlauch (160) und das dünnwandige Glied (166 oder 172) an der ihnen bestimmten

Stelle in der Hauptschlagader sitzen; wobei nach dem Entfernen jedweder solchen Hölle (160) das dünnwandige Glied aufgeweitet werden kann, um mit der Hauptschlagader in Berührung zu kommen und daran festzuhalten, damit das dünnwandige Glied (166 oder 172) und das erste Ende des Schlauches (160) an der Hauptschlagader befestigt werden.

2. Hauptschlagaderimplantat des Anspruchs 1, worin das dünnwandige Glied (166 oder 172) schlauchförmig ist, seine Wandung eine im wesentlichen gleichförmige Wandstärke hat und eine Mehrzahl von Schlitzten (173) darin ausgebildet sind, die im wesentlichen parallel zur Längsachse des dünnwandigen Gliedes angeordnet sind. 10

3. Hauptschlagaderimplantat des Anspruchs 2, worin die Schlitzte (173) peripher gleichmäßig von benachbarten Schlitzten beabstandet sind und auch entlang der Längsachse des schlauchförmigen Gliedes (166 oder 172) von benachbarten Schlitzten gleichmäßig beabstandet sind, wobei zumindest ein langgestrecktes Glied zwischen benachbarten Schlitzten ausgebildet wird. 15

4. Hauptschlagaderimplantat des Anspruchs 3, worin jeder Schlitz (173) ein erstes und zweites Ende hat, wobei das erste und zweite Ende jedes Schlitzes eine Zwischenlage zwischen ersten und zweiten Enden benachbarter Schlitzte entlang der Längsachse des schlauchförmigen Gliedes einnimmt. 20

5. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin das dünnwandige Glied (166 oder 172) keine nach aussen gerichtete radiale Kraft ausübt, während das Glied den ersten (D') oder den aufgeweiteten zweiten (D'') Durchmesser hat. 25

6. Hauptschlagaderimplantat eines beliebigen der Ansprüche 2 bis 5, worin die Schlitzte (173) von im wesentlichen rechteckiger Gestalt sind, wenn das schlauchförmige Glied den ersten Durchmesser (D') hat, aber von im wesentlichen sechseckiger Gestalt, wenn das schlauchförmige Glied den aufgeweiteten zweiten Durchmesser (D'') hat. 30

7. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin das dünnwandige Glied eine biologisch inerte Beschichtung auf der Wandungsoberfläche hat. 35

8. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin das zweite Ende des Schlauchs gegabelt ist und zwei schlauchförmige Verbindungswege (191) gebildet werden, die in Fluidverbindung mit dem ersten Ende (161) des Schlauches (160) stehen und dazu ausgeformt 40

5. sind, um in zwei Hüftschlagadern (153L, 153R) einzugehen und darin angeordnet zu werden.

9. Hauptschlagaderimplantat des Anspruchs 8, worin die beiden schlauchförmigen Verbindungswege (191) Mittel (192) einschliessen, um an den beiden Hüftschlagadern befestigt zu werden. 45

10. Hauptschlagaderimplantat des Anspruchs 9, worin zu den Befestigungsmitteln ein dünnwandiges schlauchförmiges Glied gehört, das ein erstes und zweites Ende sowie eine glatte äussere Wandungs-oberfläche zwischen dem ersten und zweiten Ende hat, wobei die Wandung eine im wesentlichen gleichförmige Wandstärke hat und eine Mehrzahl von Schlitzten darin ausgebildet sind, die im wesentlichen parallel zur Längsachse des schlauchförmigen Gliedes angeordnet sind, und wobei die Fluidverbindungswege am ersten Ende des schlauchförmigen Gliedes befestigt werden; das schlauchförmige Glied einen ersten Durchmesser hat, der seine Einführung in den Innenraum der Hauptschlagader gestattet, sowie einen zweiten, aufgeweiteten und verformten Durchmesser, der sich nach Anwendung einer radial nach aussen wirkenden Kraft vom Inneren des schlauchförmigen Gliedes her ergibt und je nach der Grösse der auf das schlauchförmige Glied ausgeübten Kraft unterschiedlich gross ist, wodurch das schlauchförmige Glied aufgeweitet und verformt werden kann, so dass das zweite Ende des schlauchförmigen Gliedes und die schlauchförmigen Verbindungswege an den beiden Hüftschlagadern befestigt werden können. 50

11. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin das erste Ende (161) des Schlauches (160) durch eine Mehrzahl von Nähten am zweiten Ende (168) des dünnwandigen Gliedes (166 oder 172) befestigt ist. 55

12. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin das erste Ende (161) des Schlauches (160), das am zweiten Ende (168) des dünnwandigen Gliedes (166 oder 172) befestigt ist, radial aufgeweitet werden kann, wodurch das erste Ende des Schlauches mit dem zweiten, aufgeweiteten und verformten Durchmesser (D'') des zweiten Endes des dünnwandigen Gliedes zusammengepasst werden kann.

13. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin der Schlauch (160) einen Zwischenabschnitt (171) hat, der radial im wesentlichen nicht aufweiterbar ist.

14. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin der Schlauch (160) geriffelt ist, um eine im Längsschnitt wellenar-

tige Gestalt anzunehmen, wodurch das Knicken und verdrehen des Schlauches auf ein Minimum reduziert wird.

15. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin zu den Befestigungsmitteln (165) ein erstes und zweites schlauchförmiges Glied (172, 172') gehören, die durch zumindest ein Verbindungsglied (196) biegsam miteinander verbunden sind, wobei das erste Ende des Schlauches (160) an einem der schlauchförmigen Glieder befestigt ist. 5

16. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin der Schlauch (160) bioerodierbar ist. 15

17. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin der Schlauch (160) für Fluidfluss durch seine Wandung undurchlässig ist. 20

18. Hauptschlagaderimplantat eines beliebigen der vorangehenden Ansprüche, worin das dünnwandige Glied (166 oder 172) schlauchförmig ist und das erste Ende (161) des Schlauches (160) das zweite Ende des schlauchförmigen Gliedes überschneidet und überdeckt. 25

19. Hauptschlagaderimplantat des Anspruchs 18, worin die Oberschneidung angenähert 50 % der Länge des schlauchförmigen Gliedes beträgt. 30

20. Vorrichtung (180) zur Behebung eines Unterleibs-Hauptschlagaderaneurysmas (151) in einer Hauptschlagader (152), mit der zwei Hüftschlagadern (153L, 153R) verbunden sind, bestehend 35

- (a) aus einem Schlauch (160) mit einem ersten und zweiten Ende (161, 162) und einer Wandungsoberfläche (163) zwischen den beiden Enden; 40
- (b) aus einem aufweitbaren und verformbaren dünnwandigen, schlauchförmigen Glied (166 oder 172) mit einem ersten und zweiten Ende (167, 168) und einer äusseren Wandungsoberfläche (169) zwischen dem ersten und zweiten Ende (167, 168), wobei das erste Ende (161) des Schlauches (160) mit dem zweiten Ende (168) das schlauchförmigen Gliedes (166 oder 172) verbunden ist und die Aufweitung und Verformung des dünnwandigen, schlauchförmigen Gliedes gesteuert werden kann; und wobei die äussere Wandungsoberfläche (169) des dünnwandigen Gliedes genügend glatt ist, damit eine den Schlauch (160) und das dünnwandige Glied (166 oder 172) umschliessende Hülle (186), die deren Einführung in das Innere 45

der Hauptschlagader dient, entfernt werden kann, indem die Hülle über die äussere Wandungsoberfläche (169) geschoben wird, während der Schlauch (160) und das dünnwandige Glied (166 oder 172) an der ihnen bestimmten Stelle in der Hauptschlagader sitzen; wobei nach dem Entfernen jedweder solchen Hülle (186) das dünnwandige Glied aufgeweitet werden kann, um mit der Hauptschlagader in Berührung zu kommen und daran festzuhalten, damit das dünnwandige Glied (166 oder 172) und das erste Ende des Schlauches (160) an der Hauptschlagader befestigt werden; und 50

- (c) aus einem Katheter (181), der einen aufweitbaren, aufblähbaren Abschnitt (182) enthält, wobei das dünnwandige schlauchförmige Glied lösbar auf den aufblähbaren Abschnitt des Katheters aufgesetzt ist und wo nach Aufblähen des aufweitbaren, aufblähbaren Abschnitts (182) des Katheters das dünnwandige, schlauchförmige Glied (166 oder 172) radial nach aussen in Berührung mit der Hauptschlagader gedrückt wird, um daran haften zu bleiben, während der am dünnwandigen, schlauchförmigen Glied befestigte Schlauch (160) einen Verbindungsweg durch das Unterleibs-Hauptschlagaderaneurysma schafft. 55

## Revendications

1. Greffe aortique (150) pour pose intraluminale permettant de réparer un anévrisme abdominal aortique (151) dans une aorte (152) présentant deux artères iliaques (153L, 153R) qui lui sont associées, comprenant : un tube (160) présentant une première et une deuxième extrémités (161, 162) et une paroi de surface (163) disposée entre les deux extrémités, au moins une portion du tube (160) étant conçue pour être placée à l'intérieur de l'anévrisme aortique abdominal (151), et des moyens (165) pour assujettir la première extrémité (161) du tube (160) à l'aorte (152), caractérisée en ce que les moyens d'assujettissement (165) comprennent un organe à parois minces (162 ou 172) présentant une première et une deuxième extrémités (167, 168), et une paroi présentant une surface extérieure (169) disposée entre la première et la deuxième extrémités (167, 168), la première extrémité (161) du tube (160) étant reliée à la deuxième extrémité (168) de l'organe à parois minces (166 ou 172), en ce que l'organe à parois minces (166 ou 172) présente un premier diamètre (D') qui permet la pose intraluminale de l'organe à parois minces dans l'aorte et un deuxième diamètre (D''), dilaté et déformé par l'application depuis l'intérieur de l'organe à parois minces d'une force d'extension radiale orientée vers l'extérieur, lequel deuxième diamètre (D'') est variable et dépend de l'intensité 50

de la force appliquée à l'organe à parois minces (166 ou 172), et en ce que la surface externe (169) de la paroi de l'organe à parois minces est suffisamment lisse pour qu'une gaine (186) renfermant le tube (160) et l'organe à parois minces (166 ou 172) pour la pose intraluminale dans l'aorte puisse être retirée en faisant glisser la gaine sur la surface extérieure (169) de la paroi, quand le tube (160) et l'organe à parois minces (166 ou 172) sont en position dans l'aorte, alors qu'après le retrait d'une telle gaine (186), l'organe à parois minces peut être dilaté en contact avec l'aorte pour y rester assujetti, de façon à assujettir l'organe à parois minces (166 ou 172) et la première extrémité du tube (160) à l'aorte.

2. Greffe aortique selon la revendication 1, dans laquelle l'organe à parois minces (166 ou 172) est tubulaire et en ce que sa paroi présente une épaisseur sensiblement uniforme et une pluralité de fentes (173), les fentes étant disposées sensiblement parallèlement à l'axe longitudinal de l'organe à parois minces.

3. Greffe aortique selon la revendication 2, dans laquelle les fentes (173) sont uniformément et circonférentiellement espacées des fentes adjacentes, et les fentes sont uniformément espacées des fentes adjacentes le long de l'axe longitudinal de l'organe tubulaire (166 ou 172), ce qui forme au moins un organe allongé entre les fentes adjacentes.

4. Greffe aortique selon la revendication 3, dans laquelle chaque fente (173) présente une première et une deuxième extrémités, et en ce que les première et deuxième extrémités de chaque fente sont disposées en position intermédiaire des première et deuxième extrémités des fentes adjacentes le long de l'axe longitudinal de l'organe tubulaire.

5. Greffe aortique selon l'une des revendications précédentes, dans laquelle l'organe à parois minces (166 ou 172) n'exerce aucune force radiale vers l'extérieur quand le premier organe a son premier diamètre ( $D'$ ) ou son deuxième diamètre ( $D''$ ) dilaté.

6. Greffe aortique selon l'une des revendications 2 à 5, dans laquelle les fentes (173) ont une configuration sensiblement rectangulaire quand l'organe tubulaire a son premier diamètre ( $D'$ ) et les fentes ont une configuration sensiblement hexagonale quand l'organe tubulaire a son deuxième diamètre ( $D''$ ) dilaté.

7. Greffe aortique selon l'une des revendications précédentes, dans laquelle l'organe à parois minces présente sur la surface de sa paroi un revêtement biologiquement inert .

5 8. Greffe aortique selon l'une des revendications précédentes, dans laquelle la deuxième extrémité du tube présente un embranchement, en ce que deux passages tubulaires (191) sont formés qui sont en communication fluide avec la première extrémité (161) du tube (160) et en ce que les deux passages (191) sont conçus pour s'assujettir et se placer à l'intérieur des deux artères iliaques (153L, 153R).

10 9. Greffe aortique selon la revendication 8, dans laquelle les deux passages tubulaires (191) comprennent des moyens (192) pour assujettir les deux passages tubulaires aux deux artères iliaques.

15 10. Greffe aortique selon la revendication 9, dans laquelle les moyens d'assujettissement comprennent un organe tubulaire à parois minces présentant une première et une deuxième extrémités et une surface de paroi extérieure lisse disposée entre la première et la deuxième extrémités, la surface de paroi ayant une épaisseur sensiblement uniforme et présentant une pluralité de fentes qui y sont formées, les fentes étant disposées sensiblement parallèlement à l'axe longitudinal de l'organe tubulaire, les passages pour fluides étant assujettis à la première extrémité de l'organe tubulaire, l'organe tubulaire présentant un premier diamètre qui permet la pose intraluminale de l'organe tubulaire dans l'aorte et l'organe tubulaire présentant un deuxième diamètre dilaté et déformé sous l'application depuis l'intérieur de l'organe tubulaire d'une force d'extension radiale orientée vers l'extérieur, lequel deuxième diamètre est variable et dépendant de l'intensité de la force appliquée à l'organe tubulaire, ce qui permet de dilater l'organe tubulaire et de le déformer pour assujettir la deuxième extrémité de l'organe tubulaire et les passages tubulaires aux deux artères iliaques.

20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 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8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 10000 10005 10010 10015 10020 10025 10030 10035 10040 10045 10050 10055 10060 10065 10070 10075 10080 10085 10090 10095 10100 10105 10110 10115 10120 10125

14. Greffe aortique selon l'une des revendications précédentes, dans laquelle le tube (160) est gaufré et a une configuration en coupe longitudinale ondulée afin d'éviter au maximum que le tube ne fasse des noeuds ou ne se torde. 5

15. Greffe aortique selon l'une des revendications précédentes, dans laquelle les moyens d'assujettissement (165) comprennent des premier et deuxième organes tubulaires (172, 172) interconnectés de façon flexible au moyen d'au moins un organe de connexion (196), la première extrémité du tube (160) étant assujettie à l'un des organes tubulaires. 10

16. Greffe aortique selon l'une des revendications précédentes, dans laquelle le tube (160) est biodégradable. 15

17. Greffe aortique selon l'une des revendications précédentes, dans laquelle la paroi de surface du tube (160) est imperméable aux fluides. 20

18. Greffe aortique selon l'une des revendications précédentes, dans laquelle l'organe à parois minces (162 ou 172) est tubulaire et la première extrémité (161) du tube (160) chevauche et recouvre la deuxième extrémité de l'organe tubulaire. 25

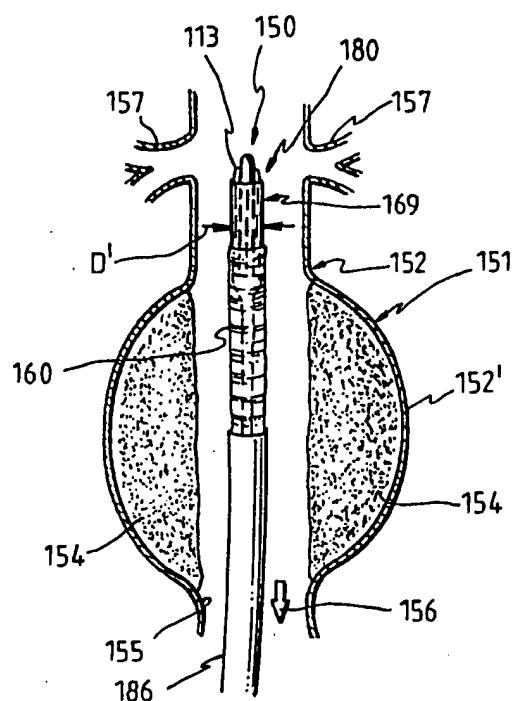
19. Greffe aortique selon la revendication 18, dans laquelle le chevauchement est d'approximativement 50% de la longueur de l'organe tubulaire. 30

20. Appareil (180) pour réparer un anévrisme abdominal aortique (151) dans une aorte (152) présentant deux artères iliaques (153L, 153R) qui lui sont associées, comprenant 35

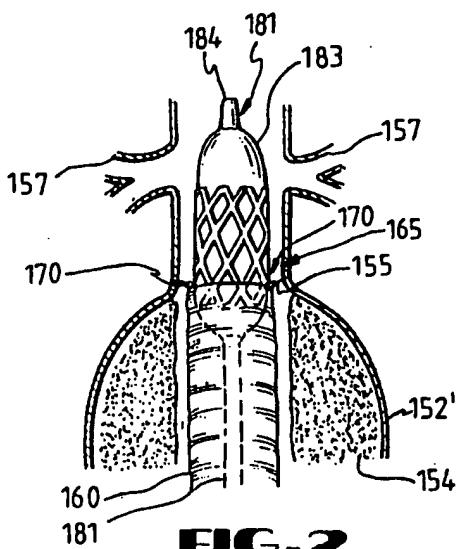
- (a) un tube (160) présentant une première et une deuxième extrémités (161, 162) et une surface de paroi (163) disposée entre les deux extrémités ; 40
- (b) un organe tubulaire extensible et déformable à parois minces (166 ou 172) présentant une première et une deuxième extrémité (167, 168), et une surface externe de paroi (169) disposée entre la première et la deuxième extrémité (167, 168), la première extrémité (161) du tube (160) étant assujettie à la deuxième extrémité (168) de l'organe tubulaire (166 ou 172), l'expansion et la déformation de l'organe tubulaire à parois minces étant contrôlables, la surface externe de la paroi (169) de l'organe à parois minces étant suffisamment lisse pour qu'une gaine (186) renfermant le tube (160) et un organe à parois minces (166 ou 172) pour la pose intraluminale dans l'aorte puisse être retirée en faisant glisser la gaine sur la surface extérieure de la paroi (169) quand le tube (160) 45
- 50
- 55

et l'organe à parois minces (166 ou 172) sont en position dans l'aorte, alors qu'après retrait de la gaine (186), l'organe à parois minces peut être dilaté en contact avec l'aorte pour rester assujetti à elle et assujettir l'organe à parois minces (166 ou 172) et la première extrémité du tube (160) à l'aorte ; et

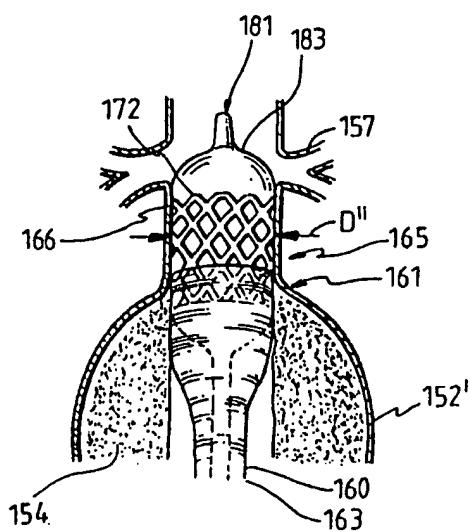
(c) un cathéter (181) présentant une partie extensible et gonflable (182) qui lui est associée, l'organe tubulaire à parois minces étant monté de façon libérable sur la partie gonflable du cathéter, tandis que par gonflage de la portion dilatable et gonflable (182) du cathéter, l'organe tubulaire à parois minces (166 ou 172) est poussé radialement vers l'extérieur en contact avec l'aorte pour y rester assujetti, tandis que le tube (160), assujetti à l'organe tubulaire à parois minces, fournit un passage à travers l'anévrisme abdominal aortique.



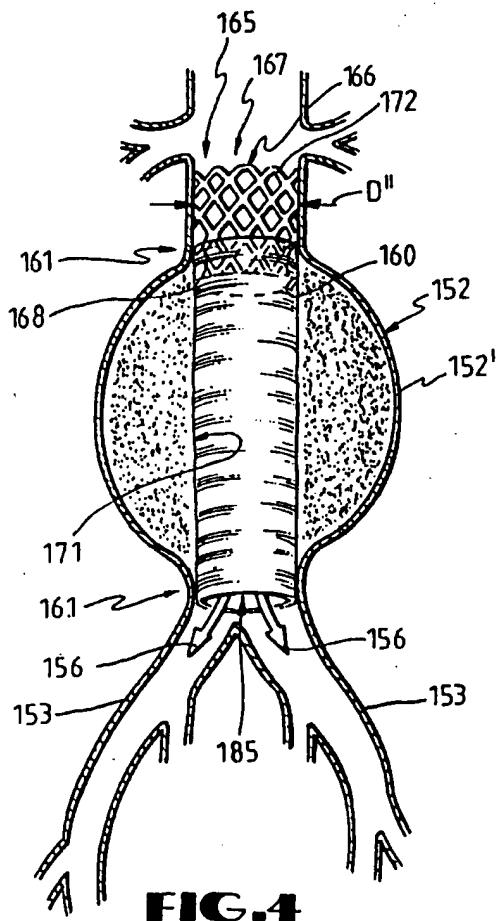
**FIG. 1**



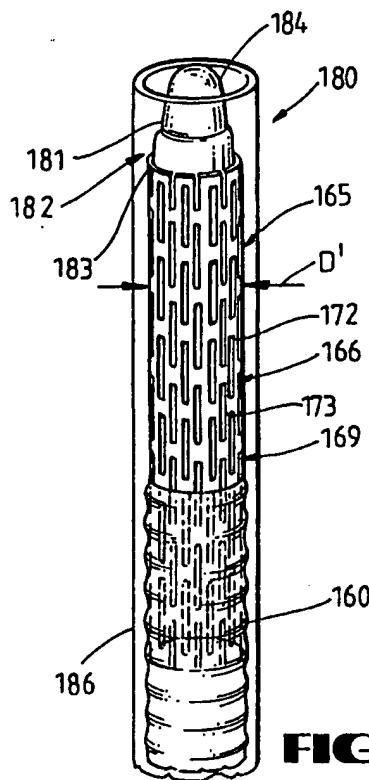
**FIG. 2**



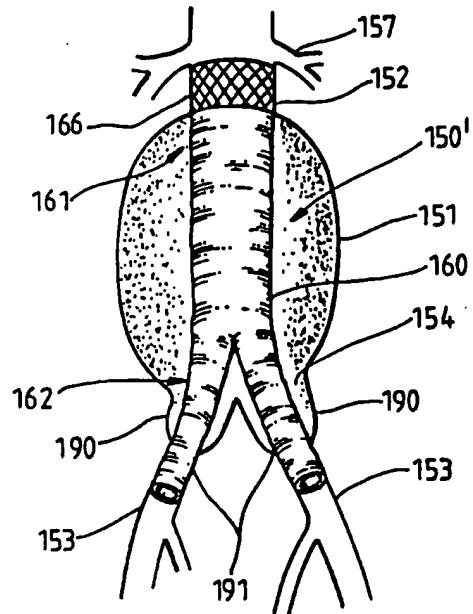
**FIG. 3**



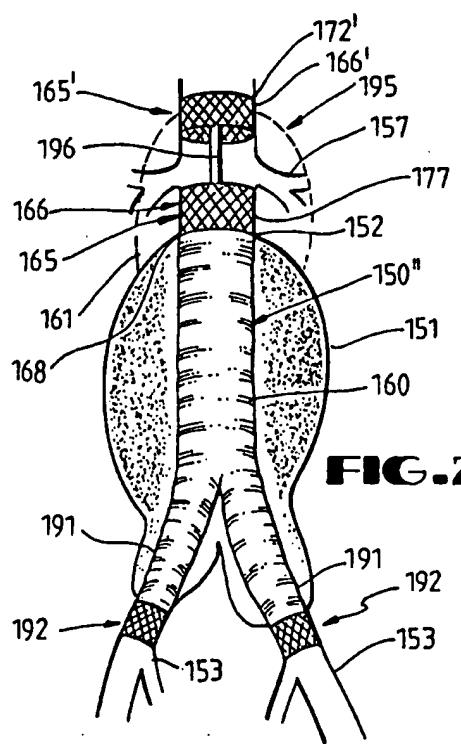
**FIG. 4**



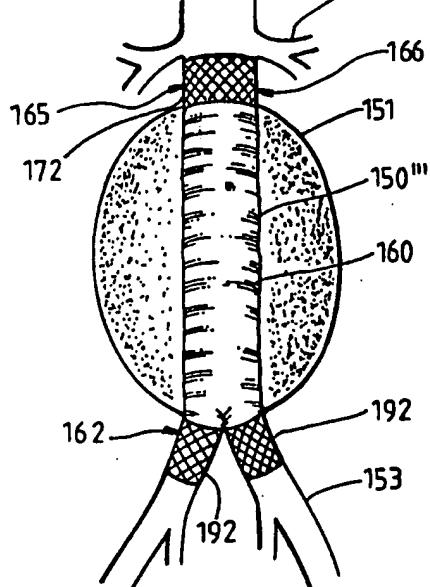
**FIG.5**



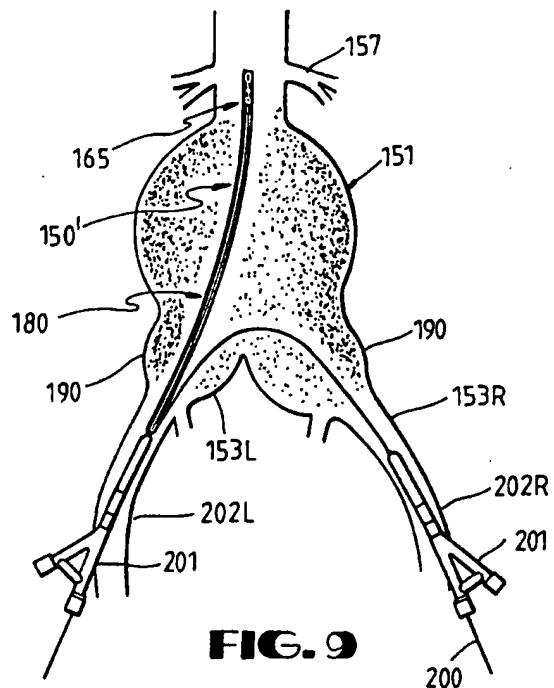
**FIG.6**



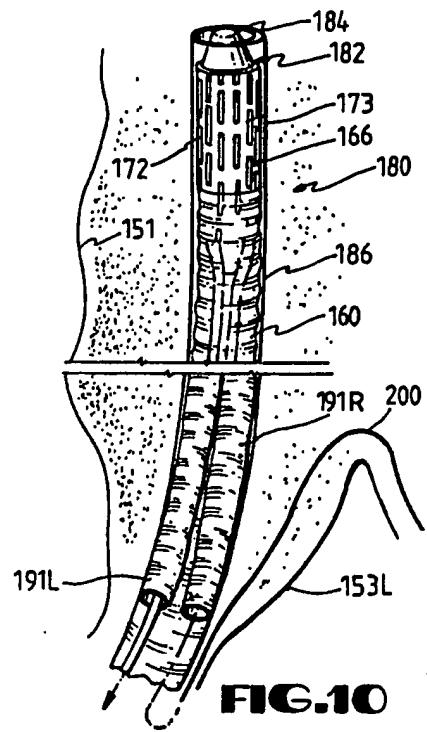
**FIG.7**



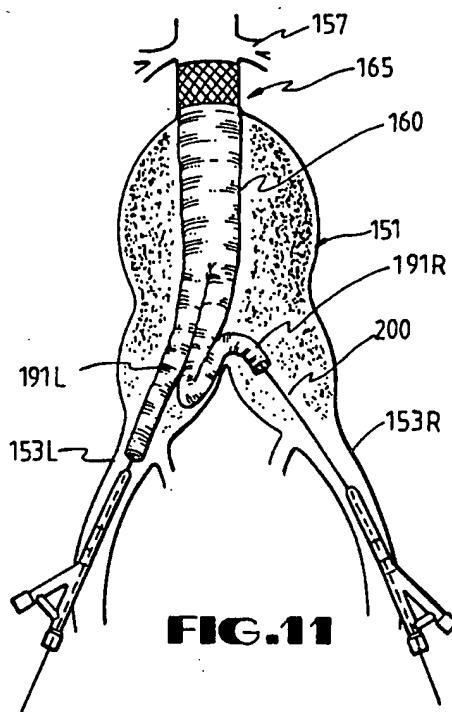
**FIG.8**



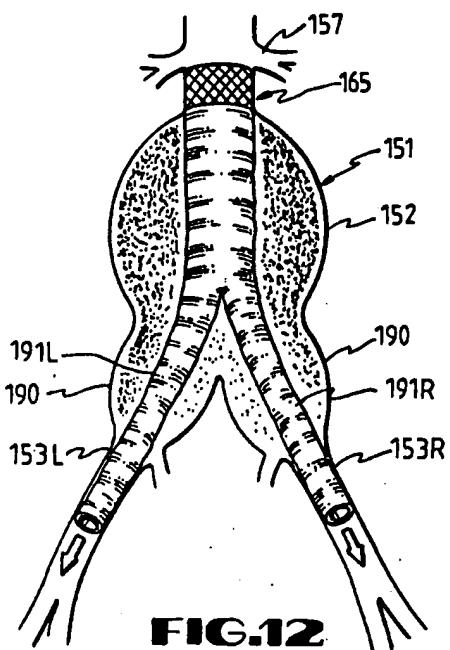
**FIG. 9**



**FIG. 10**

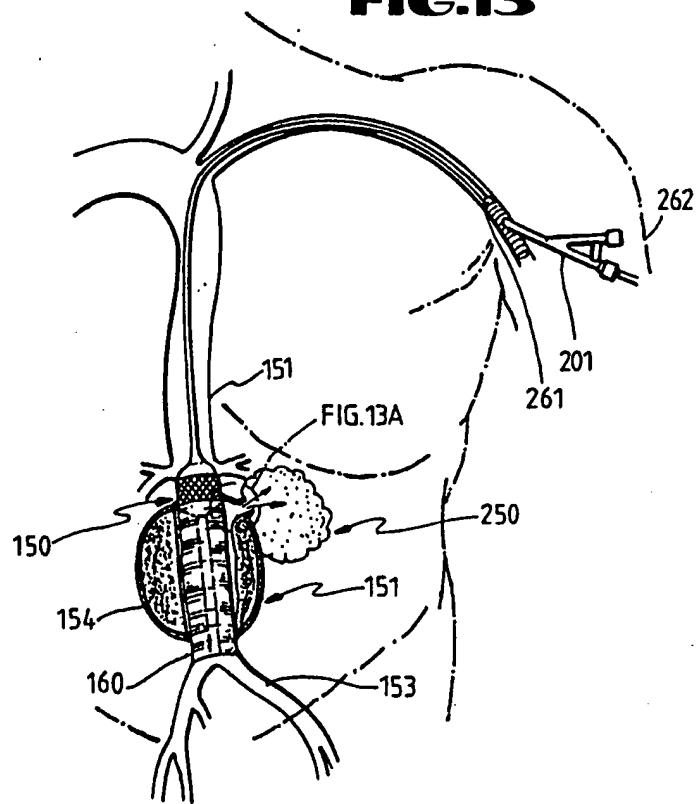


**FIG. 11**

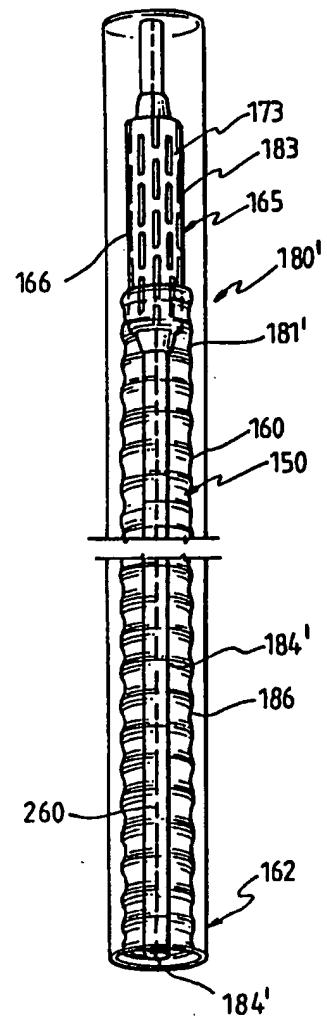
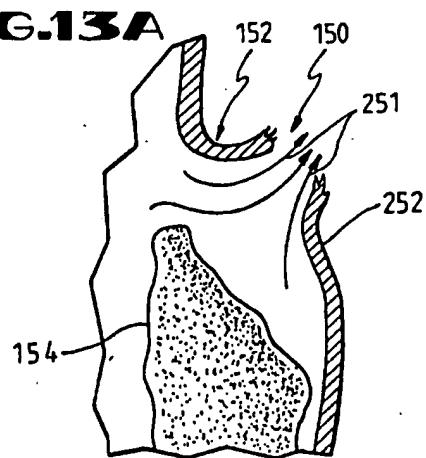


**FIG. 12**

**FIG.13**



**FIG.13A**



**FIG.14**